Реактор ПИК
и
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РНСИКС, 27-31 октября 2014, Санкт-Петербург

NEUTRON SOURCES IN THE WORLD 2014

50 reactors and 8 spallation sources

Main continuos source in Europe:

ILL - Grenoble
FRM-II - Munich
Orphée-LLB – Saclay
SINQ - PSI, Switzerland
BERII – Berlin
BNC - Budapest
IRI Delft – The Netherlands
NPL – Prague - Czech Republic
WWRM – Gatchina, Russia

+PIK (Gatchina, Russia)

World:

HFIR, NIST, ANSTO, Chalk River, China, Hanaro, Egypt, Serpong, Marocco, …

Spallation sources (Europe):

ISIS – Oxfordshire, UK
JINR – Dubna, Russia

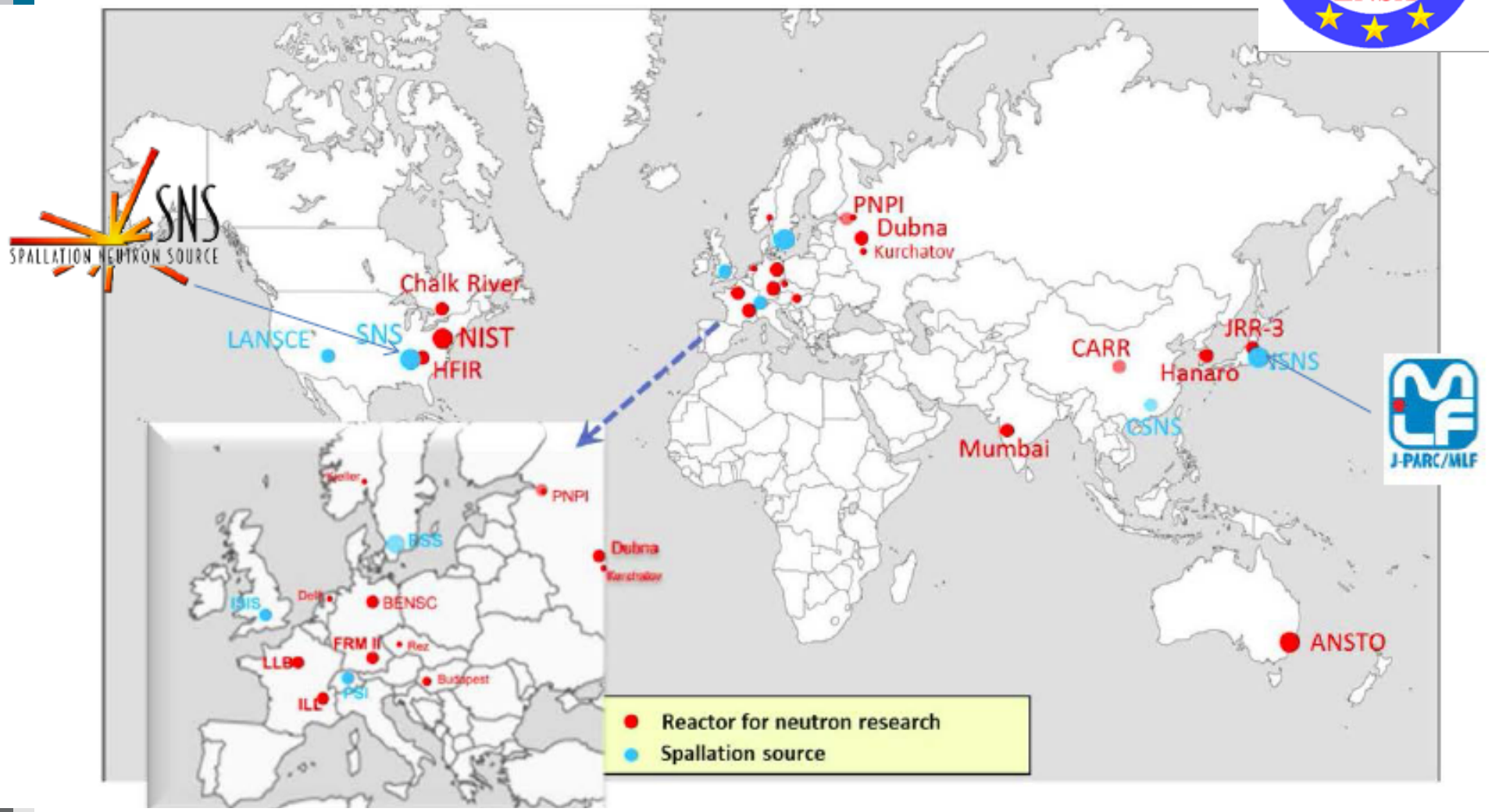
+ESS – 2019 Sweden

World:

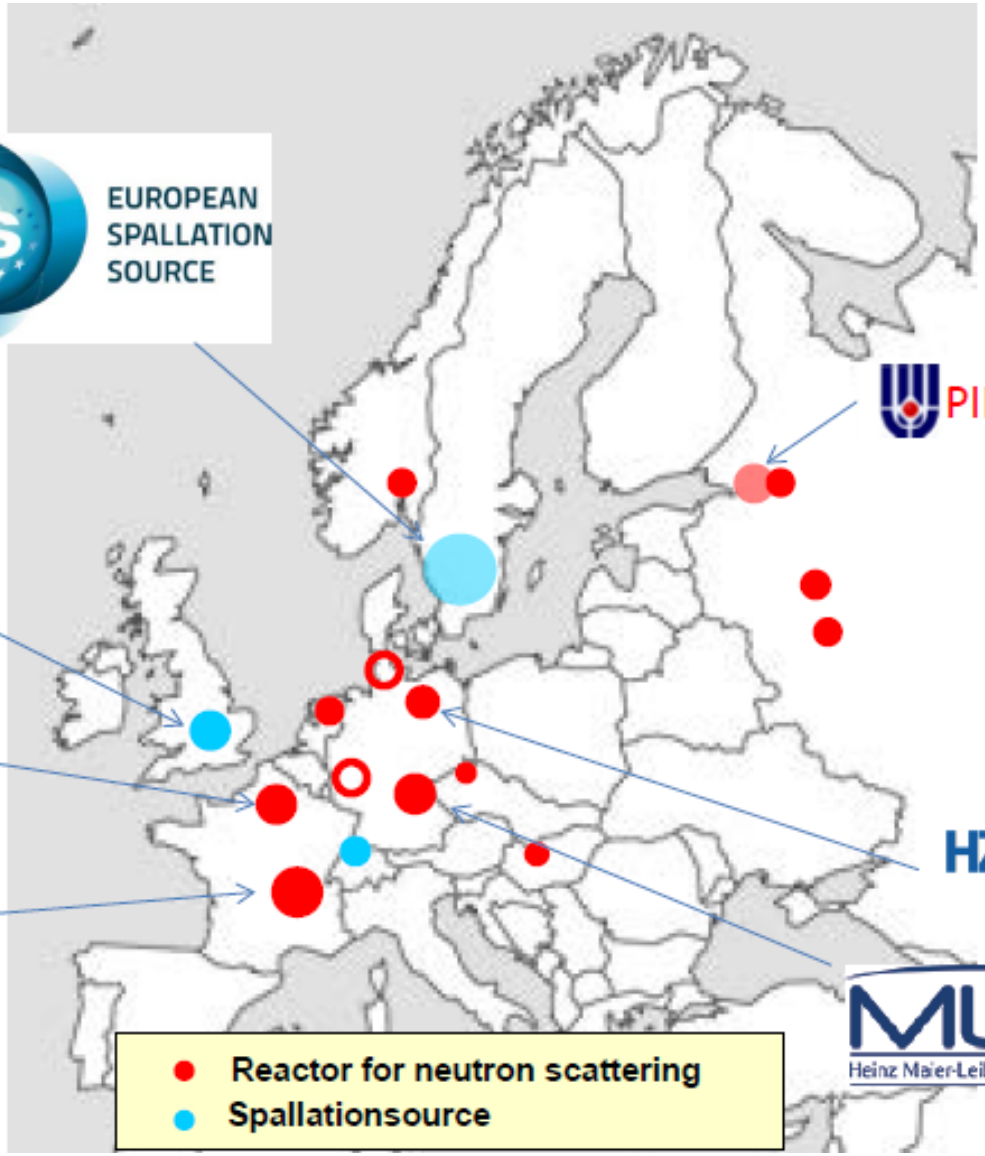
SNS – Oak Ridge – USA (2006)
J-PARC – Japan (2008)
LANSCE – Los Alamos, USA

+ C-SNS – China (?)

NEUTRON WORLD MAP

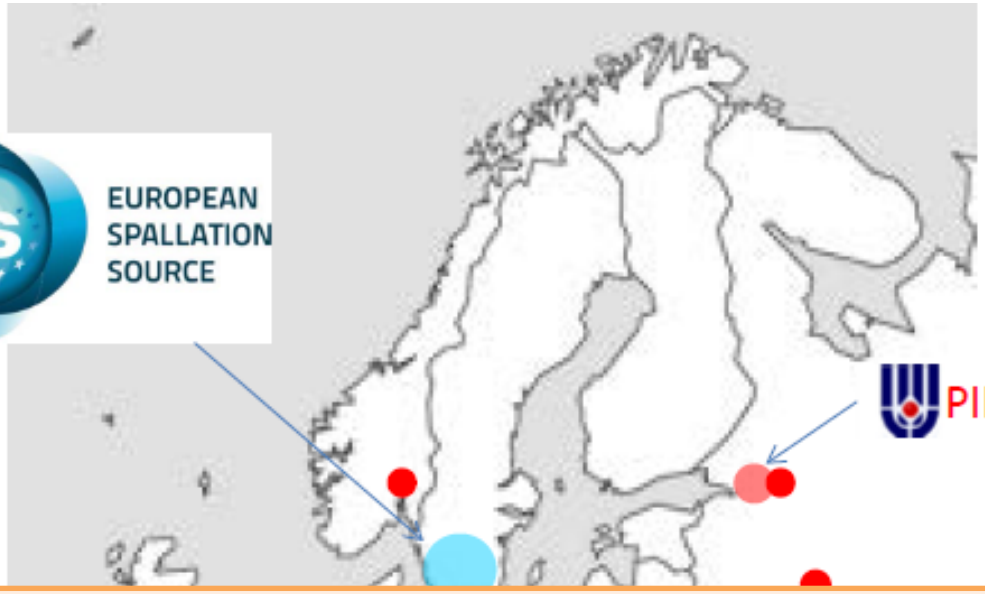


NEUTRON EUROPE MAP



BER II:
operational in POF III
till 2020

NEUTRON EUROPE MAP



Balance:
shut down of older sources in favor of modern highest performance facilities

ISIS

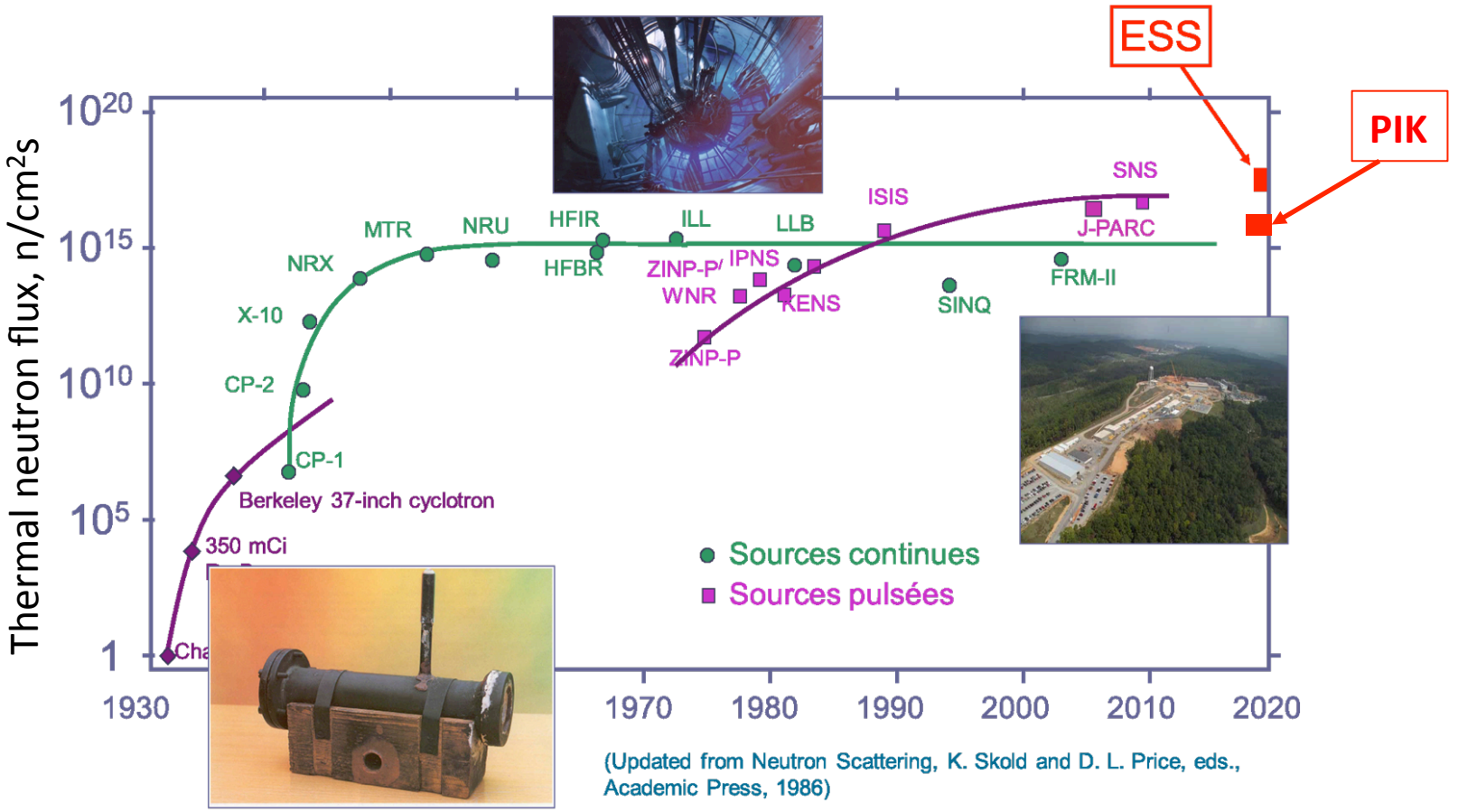
NEUTRONS FOR SCIENCE

European Landscape in 2020th :

+ first neutron at ESS
+ PIK in Russia
- BER 2 (HZB, Berlin),
- Orphée (LLB) ?,
- PSI
- ILL (2013-2023; then till when 203?)

ER II:
perational in POF III
l 2020

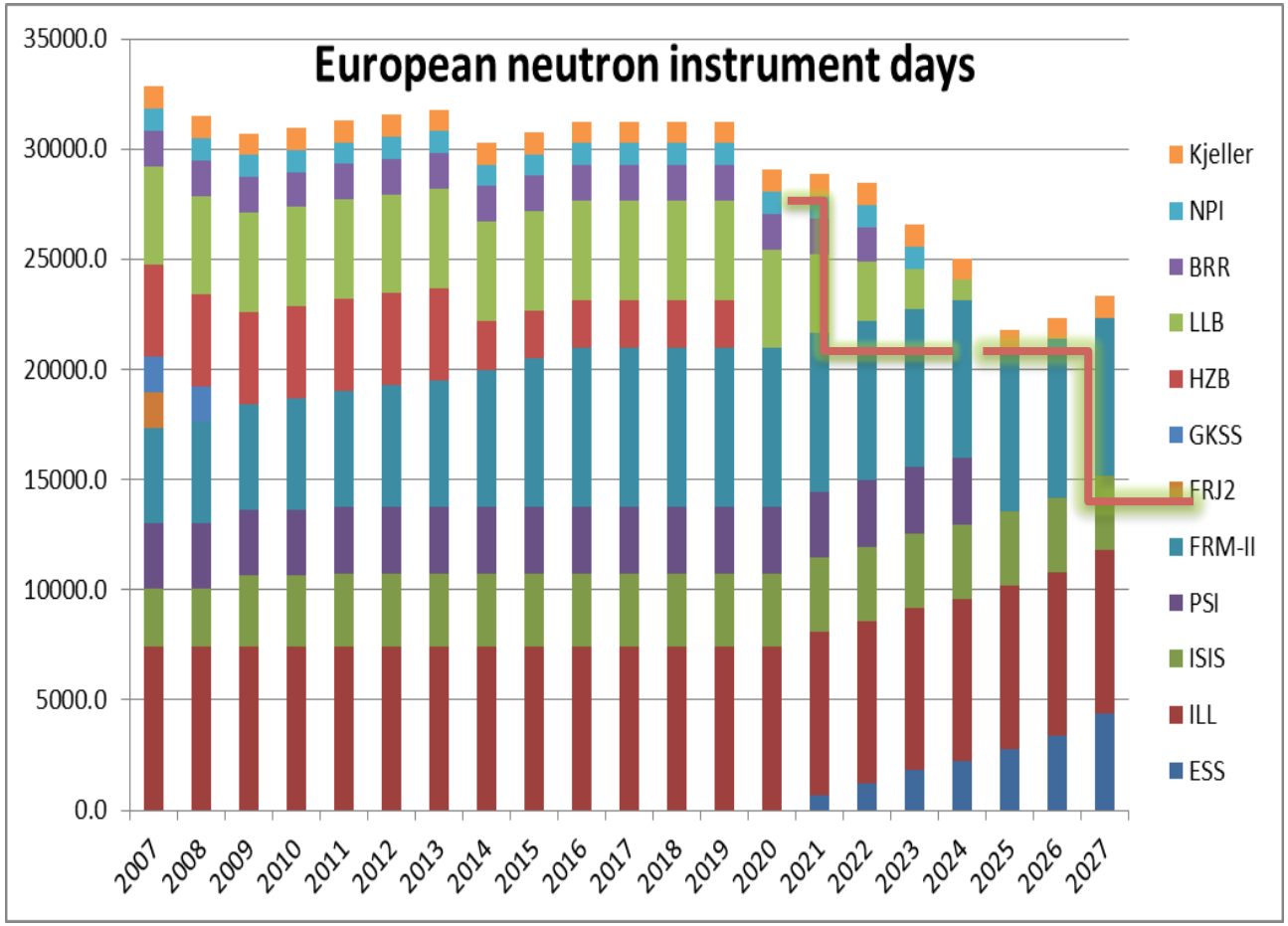
Neutron Sources: fluxes



But the real gain comes from the technical progresses on the neutron instruments!

European neutron instrument days = = (facility operating days) x (number of operational instruments).

In practice days delivered to users will be 80-85% of this value.



UK NS Roadmap by R.McGreevy

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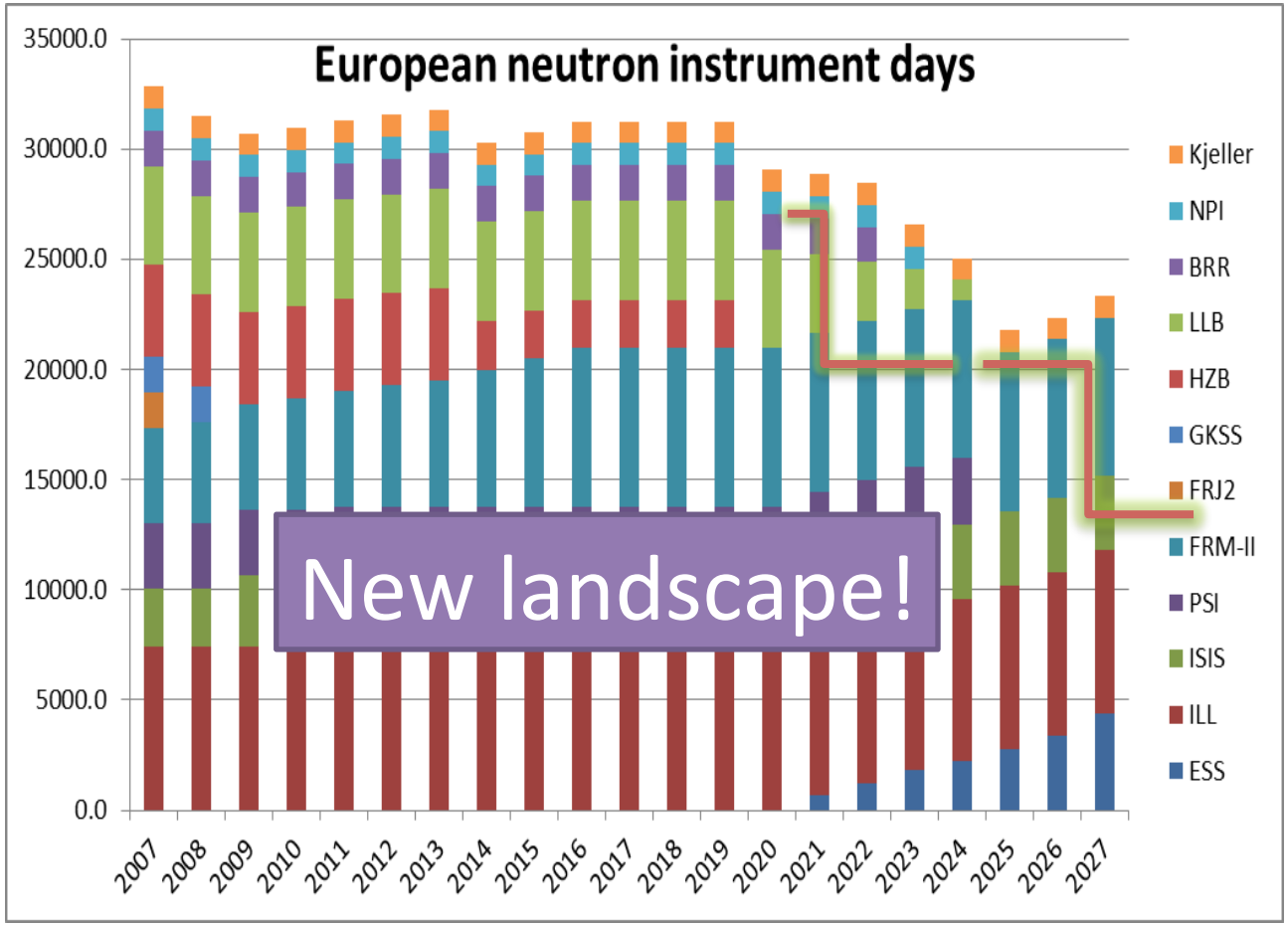

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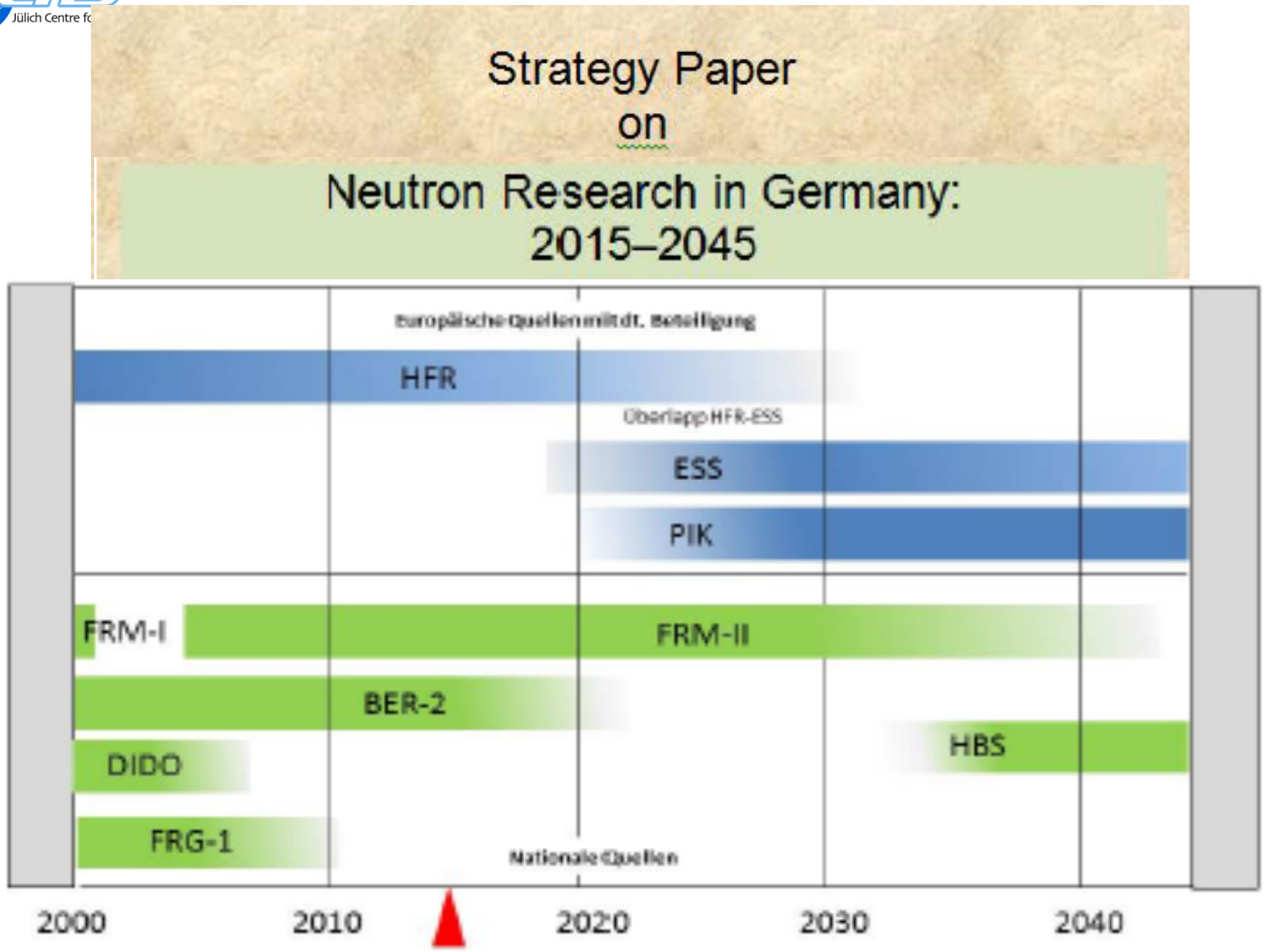
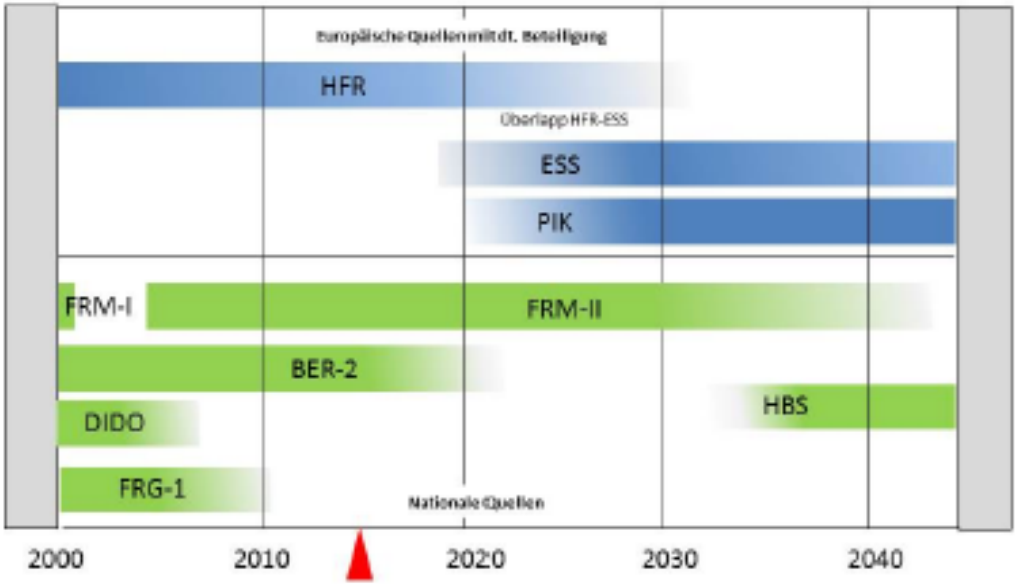


Developed last year; got full support of international reviewers in April (POF-III), is a basis for the long-term planning in BMBF

German Neutron Strategy Overview



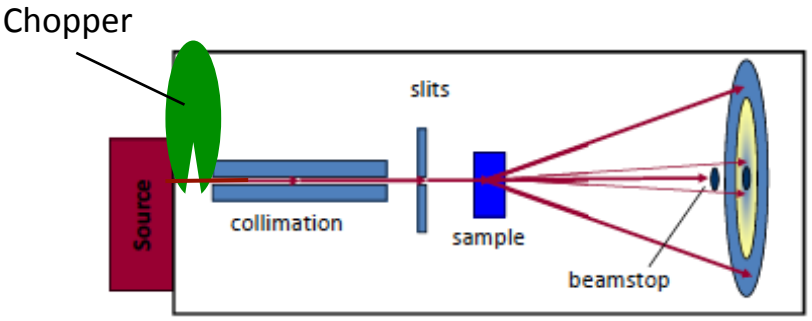
- Germany will continue to operate FRM-II and a new national spallation neutron source is an option
- ESS operation will start at the end of the decade
- HFR @ ILL Grenoble will be shut down after 2030
- PIK is an excellent chance to secure the access of the german user community to a high power neutron reactor

Why pulsed (spallation) sources?

- Politics (ecology)
- Larger neutron output/MW
- Very significant gain in the instrumental intensity

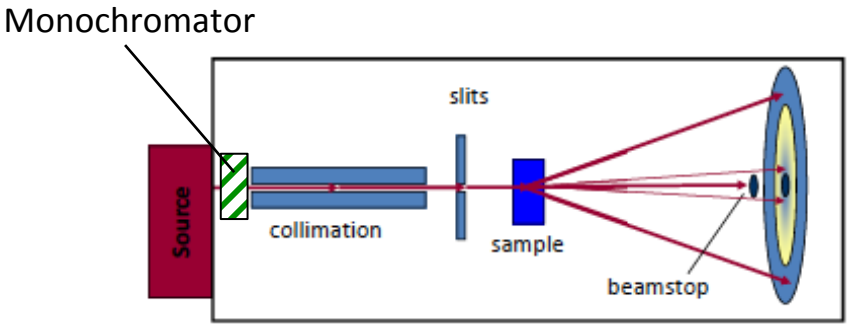
Monochromatic and TOF instruments

Time-of-flight (TOF) setup



Simultaneous coverage of a wide Q-range, however low intensity

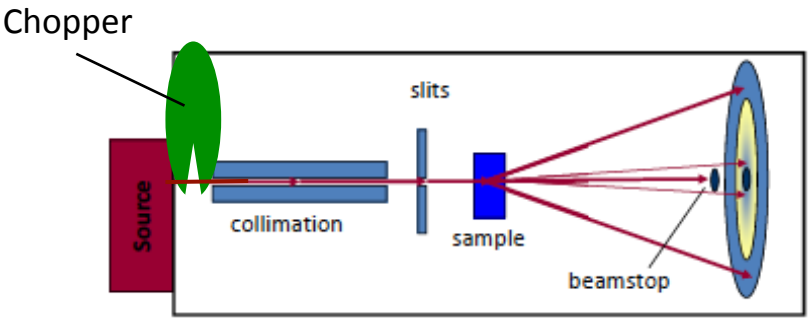
Monochromatic beam setup



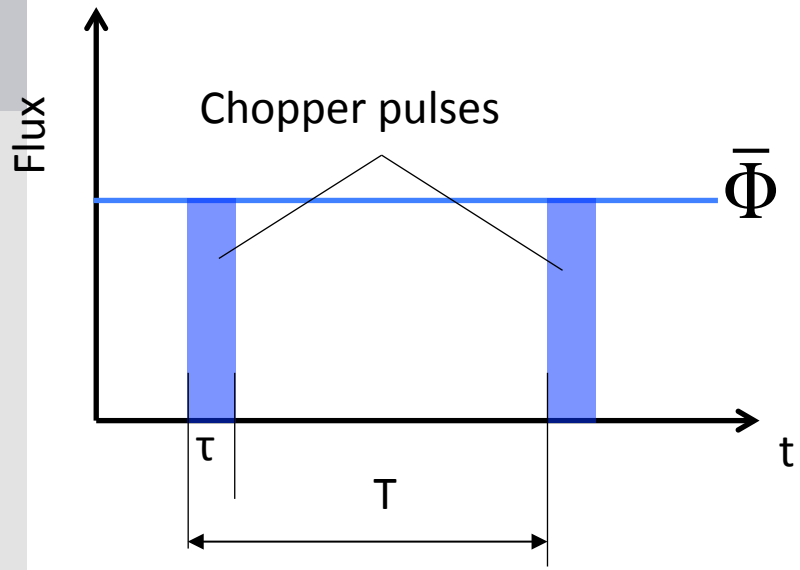
Stepwise coverage of Q-range, however high intensity

Monochromatic and TOF instruments

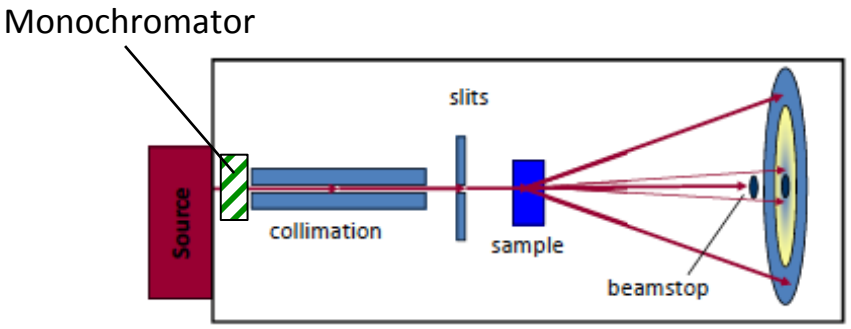
Time-of-flight (TOF) setup



Simultaneous coverage of a wide Q-range, but lower intensity:



Monochromatic beam setup



Stepwise coverage of Q-range, but higher intensity

$$\Phi_{pulse} = \frac{\tau}{T}\bar{\Phi} \approx \frac{1}{25}\bar{\Phi}$$

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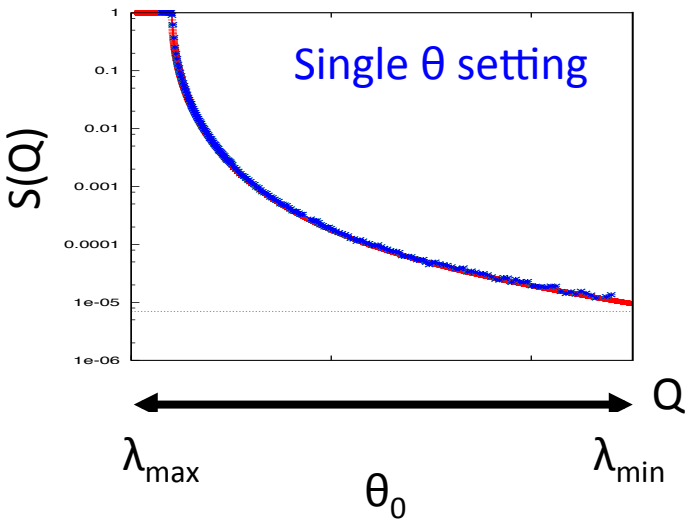
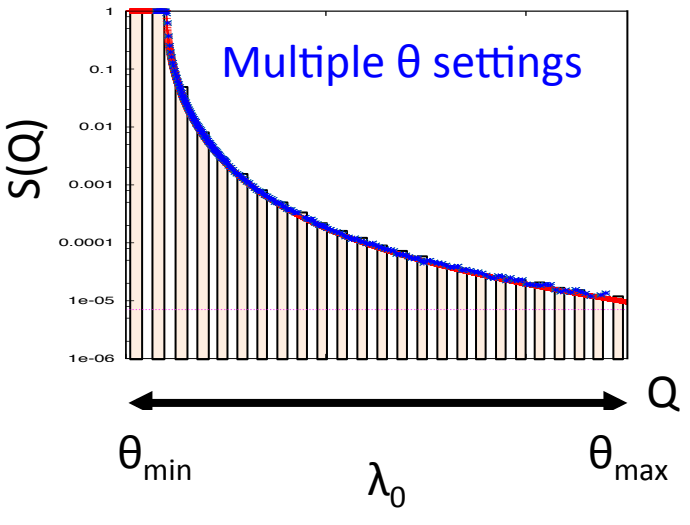
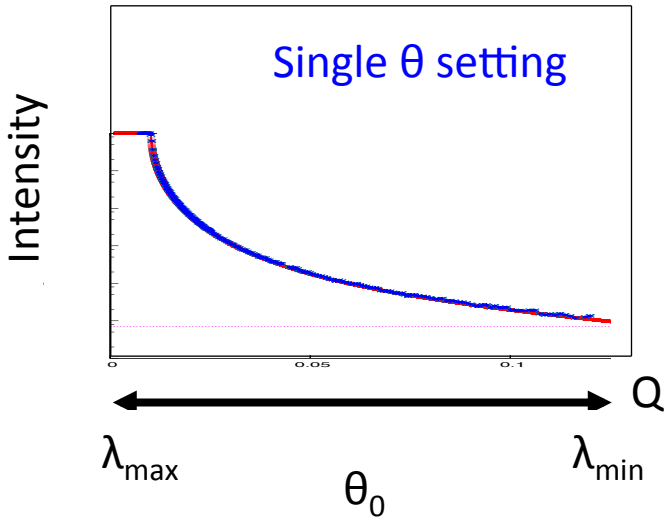
$$Q = \frac{4\pi}{\lambda}\sin\theta$$

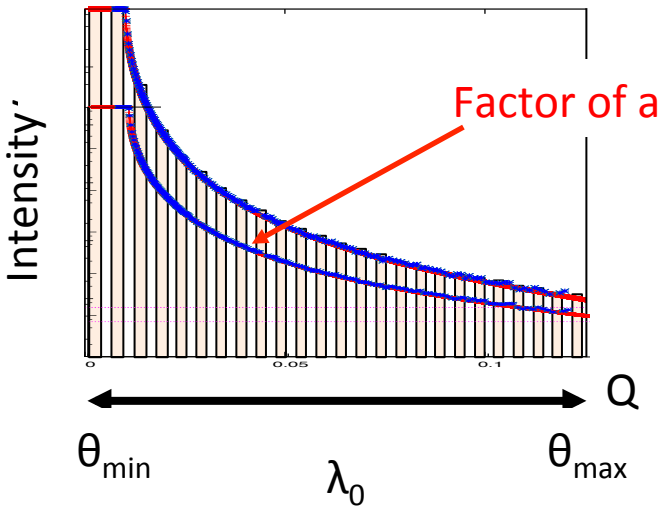
TOF: wide simultaneous Q-range



Monochromatic: stepwise coverage







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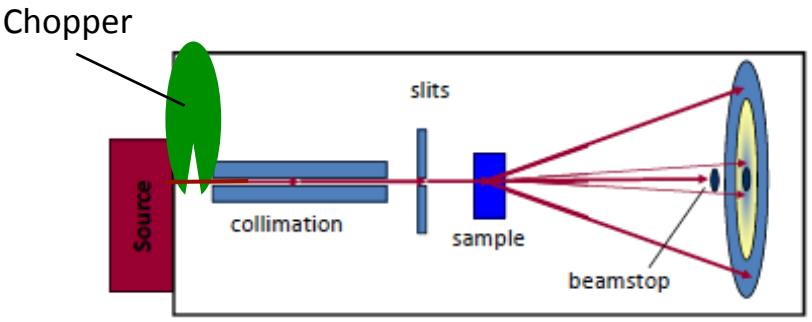
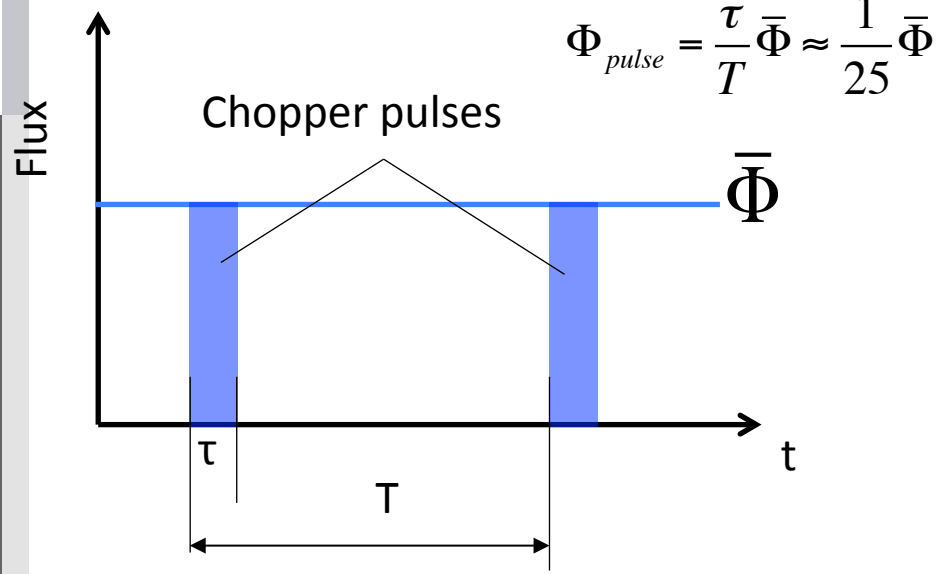
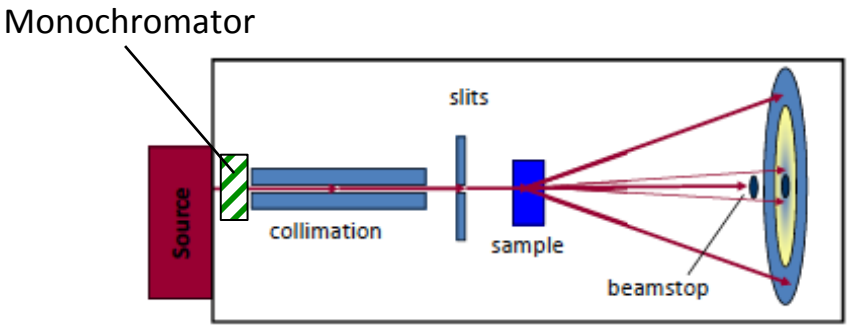


Simultaneous coverage of a wide Q-range, but lower intensity:



Monochromatic beam setup



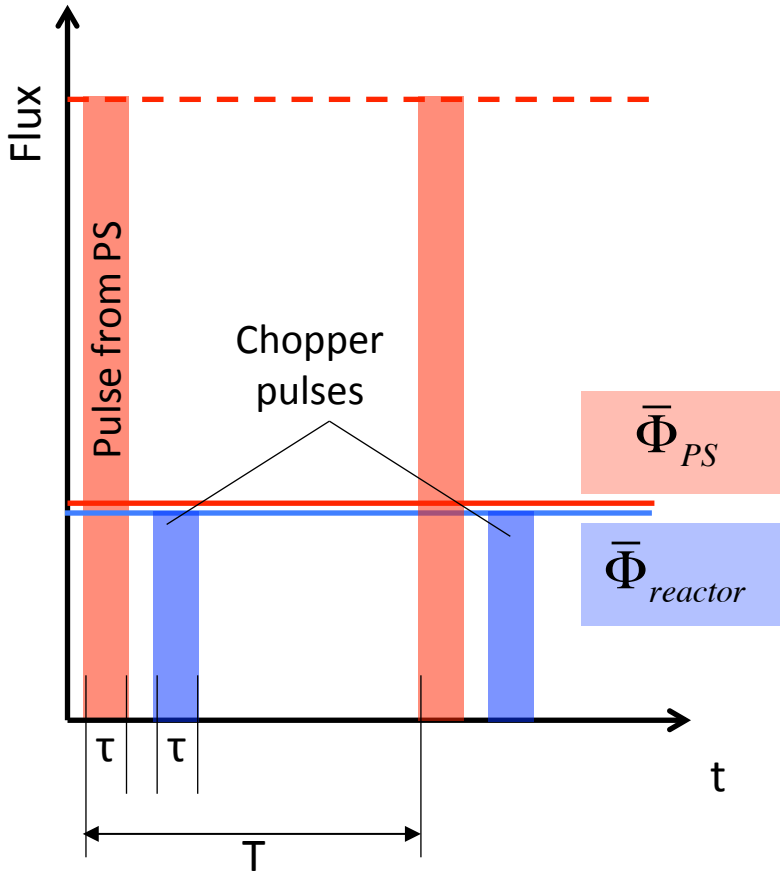
Stepwise coverage of Q-range, but higher intensity

TOF at reactor instruments: significant intensity losses that wipes out the advantage of simultaneous coverage of a wide Q-range.

⇒ *Even.*

Monochromatic instruments at reactors vs. TOF at pulsed sources.

Pulsed sources: the same average flux as at reactor source, but in peak structure

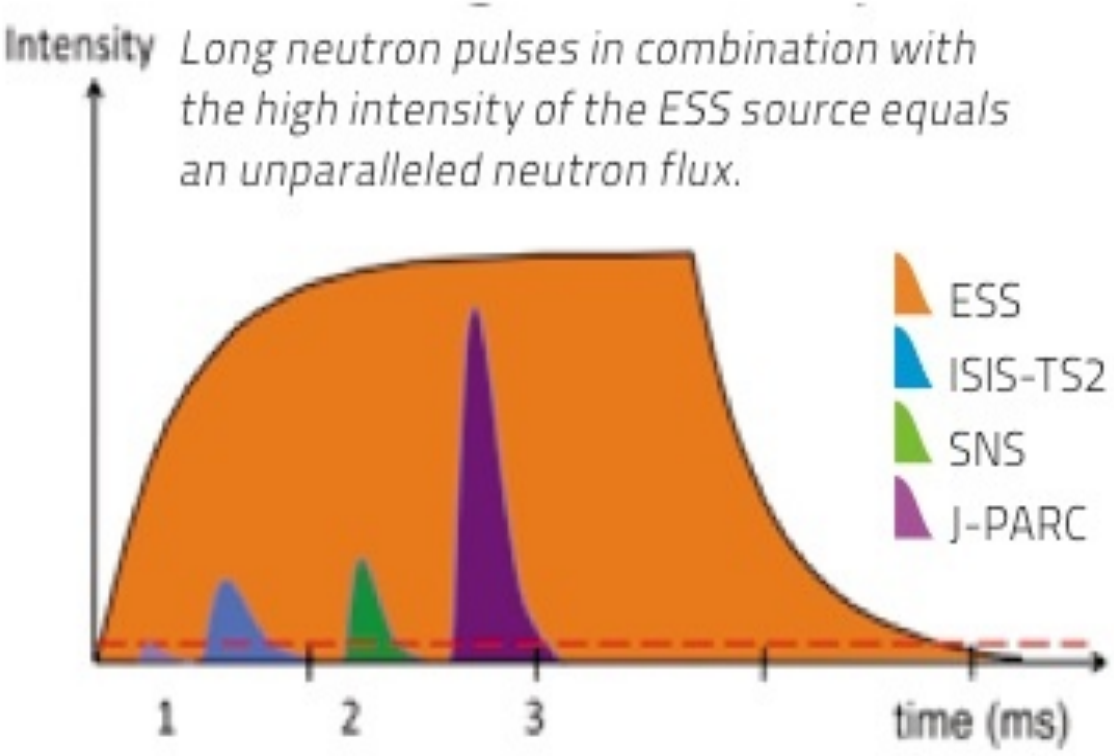


$$\bar{\Phi}_{PS} \approx \bar{\Phi}_{reactor}$$

$$\Phi_{reactor}^{pulsed} = \frac{\tau}{T}\bar{\Phi}_{reactor} > \bar{\Phi}_{reactor}$$

Pulsed sources are gaining vs. chopper pulses from reactor beams.

ESS vs. other spallation sources



Average flux of ESS ≈ ILL

- Comparison of TOF and Mono instruments at reactor and SS.

Source: ESS

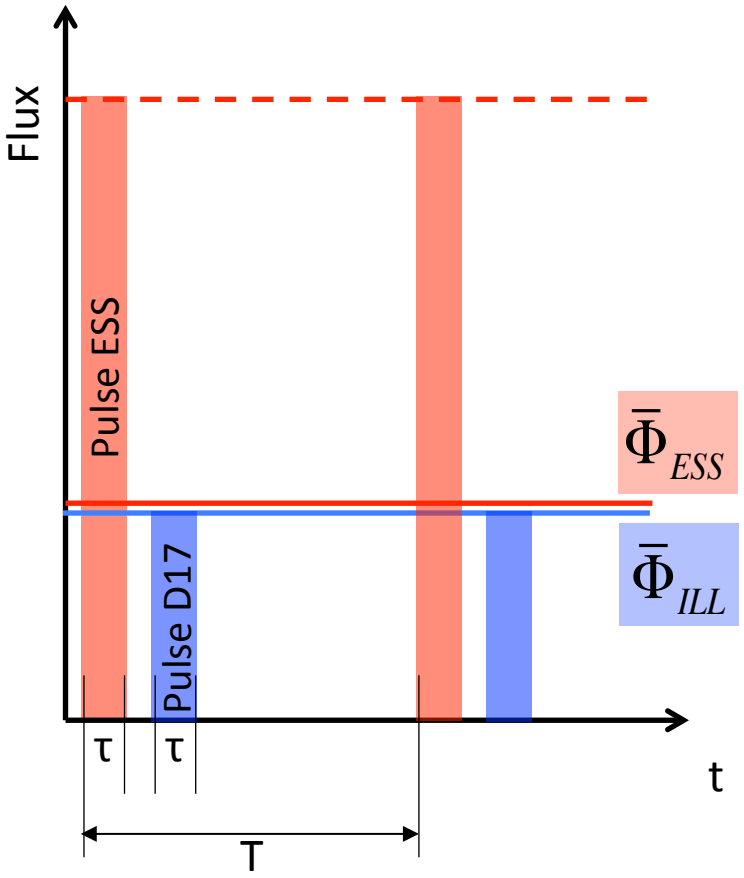
What ESS can give us?

A TOF instrument at ILL vs. a TOF instrument at ESS

If we will use the full ESS pulse, then:

$$\bar{\Phi}_{ILL} \approx \bar{\Phi}_{ESS} \qquad \Phi_{D17} = \frac{\tau}{T}\Phi_{\text{ESS Refl}} \approx \frac{1}{25}\cdot\Phi_{\text{ESS Refl}}$$

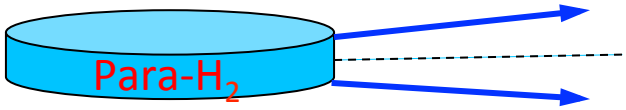
$$\tau_{ESS} = 2.8ms \qquad T_{ESS} = 72ms$$



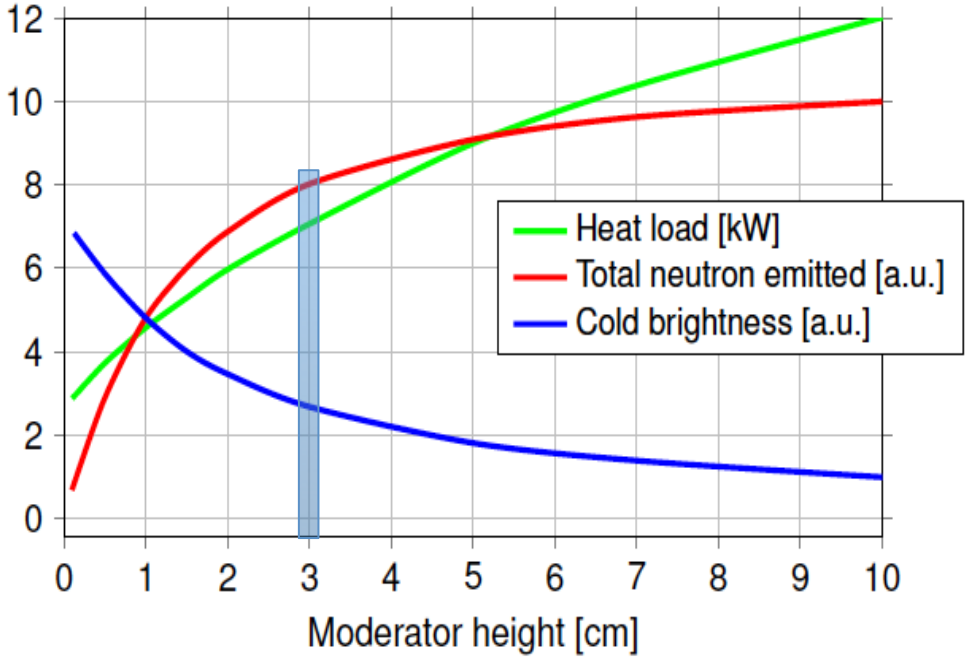
Gain against ILL is about 25!
Taking into account more modern neutron optics – 30-40!

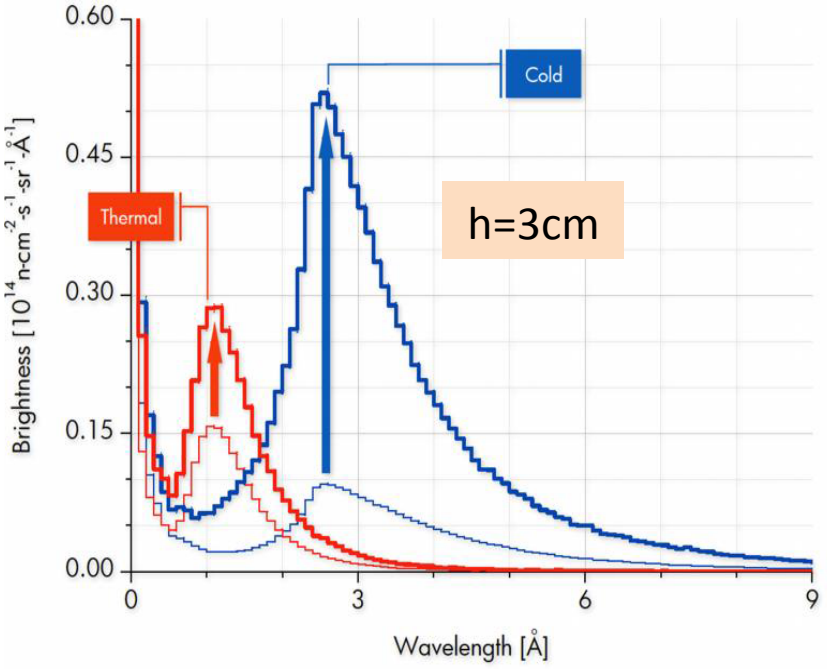
Another gain: flat moderators

a new moderator concept (F.Mezei, K.Batkov, A. Atynkbaev)



Higher brightness
in vertical plane





- At 3 cm 80 % of total neutrons emitted compared to maximum

The gain factor is 3-5 for cold neutrons and 1.5-2 for thermal neutrons for instruments that using focusing optics (small samples)

What ESS can give us?

A TOF instrument at ILL vs. a TOF instrument at ESS

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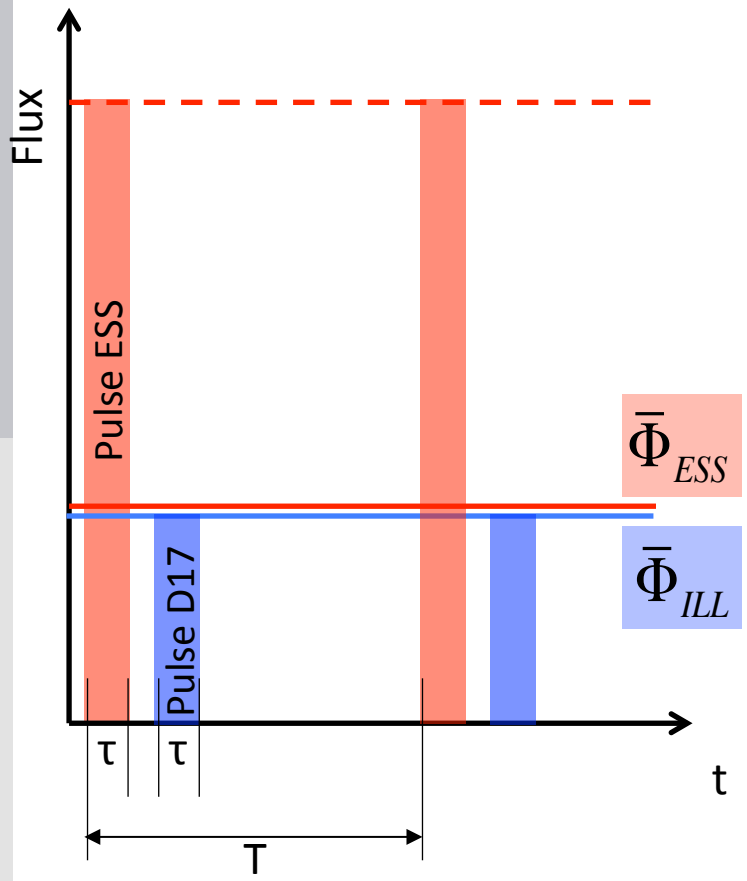


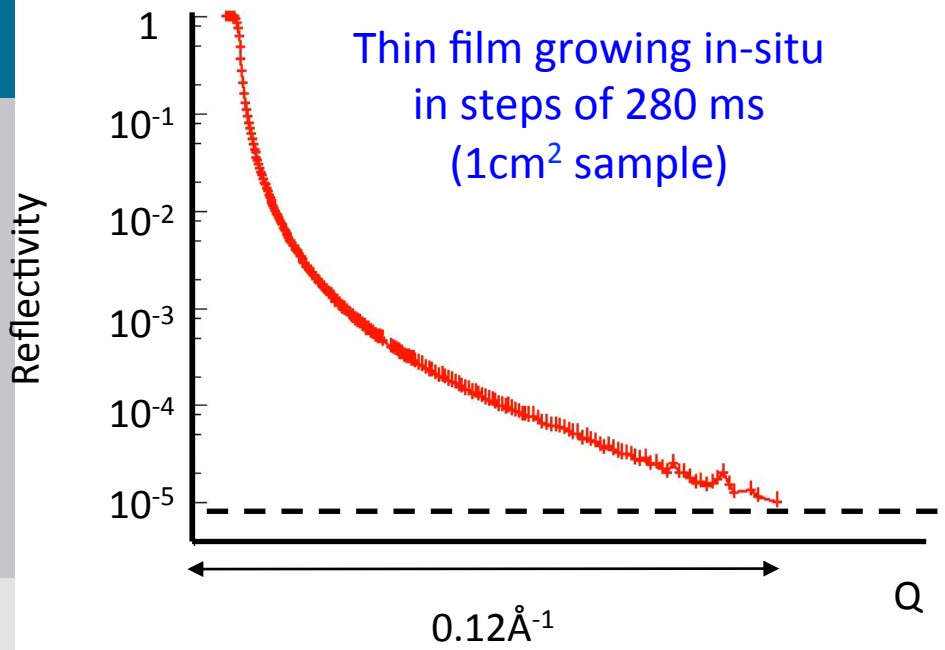
Gain against ILL is about 25!
Taking into account more modern neutron optics – 30-40!

Flat moderator – another factor 2.5-3. thus, for instruments using focusing optics the gain vs. ILL will be about 100!

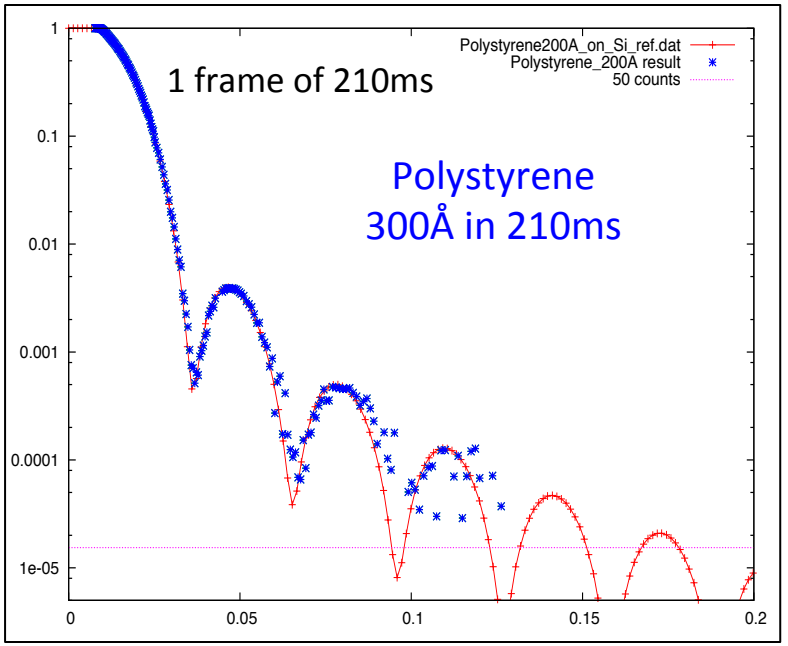
Thus ESS will provide a huge flux gain w.r.t. most intense reactor sources.

Will this result in quick and therefore a significantly larger number of experiments ?

Example: a high-intensity reflectometer at the ESS



Kinetics: **YES**

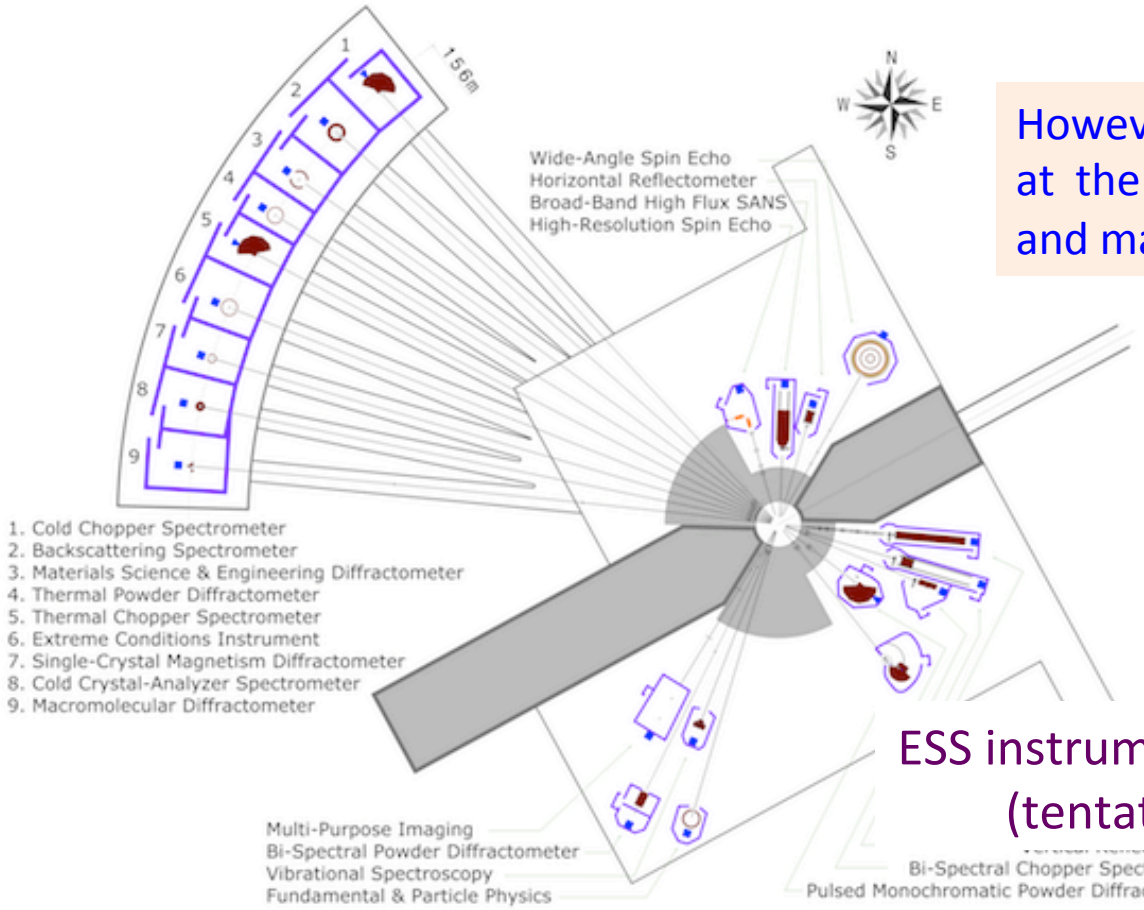


Standard reflectometry: **NO**

Changes of temperature take tens of min

Real gain is a possibility of studies of much smaller effects than today (very thin layers, low contrast, small samples, …).

But total experiment duration will be about 1 week as today

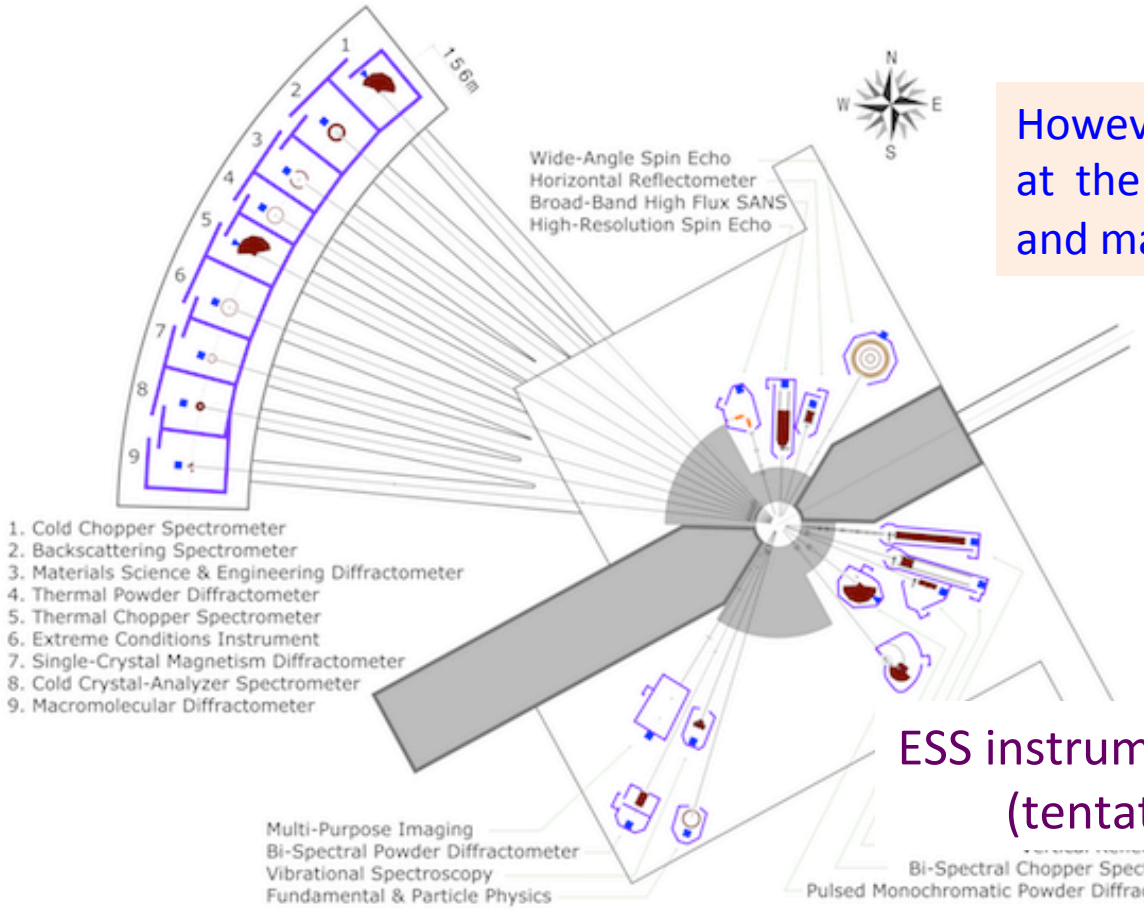


ESS instrument plan (tentative)

However, the number of instruments at the ESS is limited by only 16 (2022) and may rise to 22 instruments (2026).

ILL – about 40 instruments, MLZ– about 35 instruments

- when they will be phased out - much less instruments than today
- Inevitable loss of European user base.
- Compact neutron sources (10 to be build in Japan – similar situation)



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- Compact neutron sources (10 to be build in Japan – similar situation)
- **PIK!**

What PIK should be to play this important role? (biased point of view)

- complimentary to ESS and able to take over a large user flow

- Outstanding instrumentation:
  - Instruments answering main trends in science; the science cases for ESS shows what users are expecting.
  - PIK instruments better than at ILL & MLZ, use experience from the ESS (cf. JCNS workshop in Tutzing)
  - Much better use of reactor neutrons: better moderators, delivery systems, less background, larger solid angle, relaxing resolution till maximally possible.
  - Implementation of modern neutron technologies in neutron optics, detection, polarization analysis for better usage of scattered neutrons.
- modern methods of neutron data treatment, including visualization, graphic user interfaces, common data format and data treatment software
- Modern sample environment – reliable and on the brink of possible.

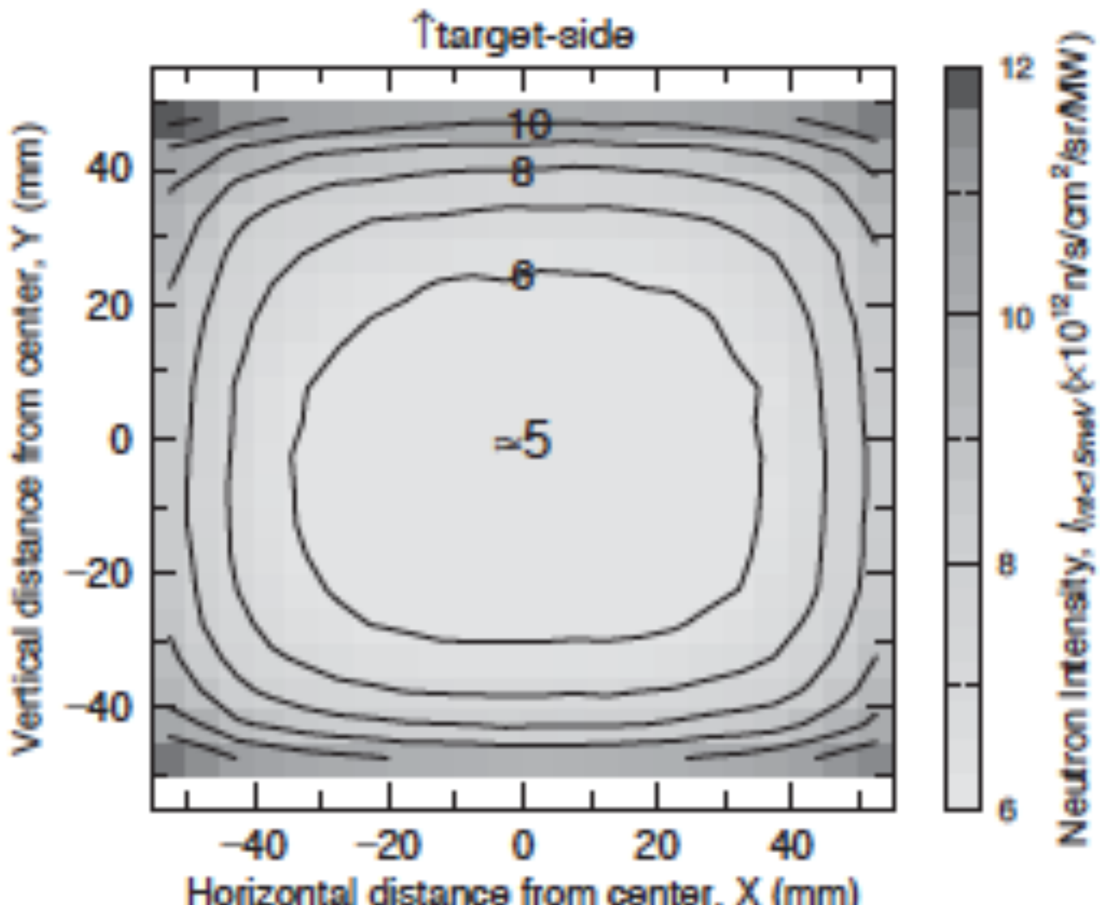
What PIK should be to play this important role? (biased point of view)

- complimentary to ESS and able to take over a large user flow

- Outstanding instrumentation
- Multidisciplinary, attraction of own non-neutron users. Building complementarity to synchrotron facilities, up to common user program. Not a competition, but cooperation!
- Less accent on short-term local interests – all user facilities went through this and the outcome is clear: 20-30% is a proper ratio to account for them.
- friendly user policy
- Inclusion of young scientists: they are the future of facilitiy

A great interest in Europe: practically every serious scientific leader understands a great value of PIK to keep the neutron community (and therefore the neutron sources) alive in a long-term.

THANK YOU FOR ATTENTION!



↑target-side
10
8
6
≈5
40
20
0
−20
−40
Vertical distance from center, Y (mm)
−40
−20
0
20
40
Horizontal distance from center, X (mm)
12
10
8
6
Neutron Intensity, (×10^12 n/s/cm^2/sr/MW)